

REMARKS

Claims 1-24 were previously pending in this application. Claims 16-24 were previously withdrawn from consideration and claims 1-15 have been rejected. Claims 16-24 are hereby cancelled and claims 11-13 and 15 have been amended. Applicants respectfully submit that, in view of the remarks provided, each of pending claims 1-15 is in patentable form.

I. Objection to the Drawings:

In the Office Action, specifically in paragraph 2, the drawings were objected to for failing to comply with 37 CFR §1.84(p)(5) because "they include the following reference sign(s) not mentioned in the description: the reference numbers '29' in FIG. 3 and '109' in FIG. 6 are not disclosed in the Specification". Formal Drawings are submitted herewith. Responsive to this objection, FIGS. 3 and 6 of the Formal Drawings are distinguished from the Informal Drawings in that the Formal Drawings do not include references numbers 29 and 109 objected to by the Examiner. Therefore, this objection to the drawings is obviated.

Furthermore, in the Office Action, specifically in paragraph 3, the drawings were objected to under 37 CFR §1.84(p)(4) because "reference characters '109' and '111' in FIG. 6 have both been used to designate a barrier layer film". Since reference character 109 has been removed from FIG. 6 as above, this objection to the drawings under 37 CFR §1.84(p)(4) is also obviated.

The drawings therefore comply with 37 CFR §1.84(p)(5) and 37 CFR §1.84(p)(4) and are in acceptable form. Each of the objections to the drawings should therefore be withdrawn.

II. Claim Rejections under 35 U.S.C. §102

In the Office Action, specifically in paragraph 6, claims 1, 3-5, 9 and 10 were rejected under 35 U.S.C. §102(e) as being anticipated by Chooi et al. (U.S. Pat. No.

6,265,321), hereinafter "Chooi". Applicants respectfully submit that these claim rejections are overcome based on the remarks set forth below.

Independent claim 1 recites the following features:

"a barrier layer disposed between a copper-containing structure and a low-k dielectric film . . . "

The cited reference of Chooi does not teach a barrier layer disposed between a copper-containing structure and a low-k dielectric film because Chooi *does not teach a low-k dielectric film*. As such, independent claim 1 recites features that distinguish applicants' invention from the cited reference of Chooi.

The Office Action states, in the sentence bridging pages 3 and 4, that "Chooi et al. discloses in FIG. 16, column 5, line 51, and column 6, lines 6-17 a semiconductor product comprising . . . a low-k dielectric film (50)". Applicants respectfully submit that second intermetal dielectric layer IMD2 50 of Chooi is not a *low-k dielectric film*. IMD2 50 is not disclosed to be a low-k dielectric film, nor does Chooi suggest that the material which forms IMD2 50, is a low-k dielectric material.

Rather, Chooi is directed to lowering the dielectric constant of a structure by forming **air plugs** within the structure: "the dielectric constant of the intermetal dielectric is lowered by introducing air into the intermetal dielectric between metal interconnections", Chooi, abstract, lines 4-6. Chooi clearly does not disclose or suggest that IMD2 50 is a low-k dielectric material. It is the air, not the ILD2 film, that possesses the low-k dielectric characteristics, and air is clearly not a "film". In fact, applicants respectfully submit that Chooi *teaches away* from the need to form a **film** that is a low-k material because of the air plugs Chooi introduces in between the films. Moreover, an examination of FIG. 16 of Chooi, reveals that the air plugs are formed within voids of layer 34 which the Office action characterizes as one of the barrier layers, and not ILD2 film 50.

In summary, then, ILD2 film 50 is not a low-k dielectric film as alleged in the Office action. Chooi simply does not disclose a low-k dielectric film. Hence, neither of Chooi's barrier layers 24 and 34 are disposed between a low-k dielectric film and

any other structure because the only low-k dielectric feature in Chooi is the air plugs, which exist within voids of barrier layer 34.

Therefore, independent claim 1 includes features neither disclosed nor suggested by the cited reference of Chooi. Since independent claim 1 is distinguished from Chooi, the rejection of claim 1 under 35 U.S.C. §102(e), should be withdrawn. Claims 3-5 and 9 each depend, directly or indirectly, from independent claim 1 and therefore also include features which distinguish applicants' invention from Chooi. The rejection of claims 3-5 and 9 under 35 U.S.C. §102(e) as being anticipated by Chooi, should therefore also be withdrawn.

Independent claim 10 recites the feature of a semiconductor product "comprising a barrier layer disposed between a readily-oxidizable conductive material and a low-k dielectric film . . ." and is similarly distinguished from the reference of Chooi which does not disclose a low-k dielectric film, for reasons set forth above.

The rejection of claim 10 under 35 U.S.C. §102(e) as being anticipated by Chooi, should therefore also be withdrawn.

III. Rejection of Claim 2 Under 35 U.S.C. §103

In the Office Action, specifically in paragraph 8, claim 2 was rejected under 35 U.S.C. §103(a) as being unpatentable over Chooi in view of Kariya et al. (U.S. Pat. No. 5,456,762), hereinafter "Kariya". Applicants respectfully submit that this claim rejection is overcome based on reasons set forth below.

Claim 2 depends directly from independent claim 1 which is distinguished from Chooi for reasons set forth above. The reference of Kariya has apparently been relied upon for providing a nitrogen-doped silicon carbide and an oxygen-doped silicon carbide. Kariya therefore does not make up for the above-stated deficiencies of Chooi. Moreover, Kariya does not teach or suggest the feature of a composite barrier layer disposed between a copper-containing structure and a low-k dielectric film as recited in claim 1 and therefore

incorporated into claim 2 by way of dependency. Claim 2 is therefore distinguished from the references of Chooi and Kariya, taken alone or in combination.

Moreover, applicants respectfully submit that the ordinary artisan would not have been motivated to modify the teachings of Chooi using the teachings of Kariya to decrease light absorption as suggested in the Office action, because Chooi is directed to integrated circuits and Kariya to photoelectric conversion elements and the effect of decreased light absorption provided by Kariya, would have no significant effect on the integrated circuits of Chooi.

As such, the rejection of claim 2 under 35 U.S.C. §103(a) as being unpatentable over Chooi in view of Kariya, should be withdrawn.

IV. Rejection of Claims 6, 7, 11, 12, 14 and 15 under 35 U.S.C. §103

In the Office Action, specifically in paragraph 9, claims 6, 7, 11, 12, 14 and 15 were rejected under 35 U.S.C. §103(a) as being unpatentable over Chooi, in view of Bjorkman et al. (U.S. Pat. No. 6,340,435), hereinafter “Bjorkman”. Applicants respectfully submit that these claim rejections are overcome based on remarks set forth below.

*** Claims 6 and 7**

Claims 6 and 7 depend from claim 1 which is distinguished from the reference of Chooi for reasons set forth above. Claims 6 and 7 also recite the feature of an oxygen-doped silicon carbide layer. With respect to dependent claims 6 and 7, the cited reference of Bjorkman has apparently been relied upon for providing an oxygen-doped silicon carbide as an insulating film and an insulating hardmask. Even if Bjorkman taught an oxygen-doped silicon carbide film as alleged by the Examiner, Bjorkman would not make up for the above-stated deficiencies of Chooi and dependent claims 6 and 7 would be distinguished from the references of Chooi and Bjorkman, taken alone or in combination.

Applicants respectfully point out that Bjorkman does not disclose an oxygen-doped silicon carbide layer, however. In the first passage cited in the Office action (column 3, lines 24-27), Bjorkman discloses a layer “that contains silicon, oxygen, carbon and

hydrogen, preferably at least about 5% carbon by atomic weight and at least about 1% hydrogen by atomic weight". In the second passage cited in the Office action (column 6, lines 40-41) Bjorkman discloses "a hard mask such as a silicon oxide layer containing carbon or hydrogen". Applicants respectfully submit that a layer that contains silicon, oxygen, carbon and hydrogen is distinguished from the claimed layer of oxygen-doped silicon carbide which is a particular, distinguishing material that includes the chemical compound of silicon carbide, that is, silicon chemically bonded to carbon in a particular, ordered manner. Similarly, a silicon oxide layer containing carbon is also distinguished from oxygen-doped silicon carbide because silicon oxide and silicon carbide are different chemical compounds. Claims 6 and 7 each recite oxygen-doped silicon carbide and are therefore further distinguished from Bjorkman.

Each of dependent claims 6 and 7 recite a further low-k dielectric film and an oxygen-doped silicon carbide hardmask. Applicants note that the Office Action alleges that film 68 of Chooi is a further low-k dielectric film. Applicants respectfully point out that the IMD4 film 68 of Chooi, like IMD2 film 50, is not disclosed or suggested to be a low-k dielectric film in the specification of Chooi. Additionally, the Office Action refers to Chooi's capping layer 70 as "insulating hardmask (70)". Applicants respectfully point out that capping layer 70 of Chooi is not disclosed or suggested to be a hardmask. A hardmask is used as an etch resistant layer to assist in patterning subjacent layers by masking them. Capping layer 70 is alternatively referred to as "organic material 70" (col. 8, line 57) or reactive material 70 in col. 9, line 20. As such, applicants respectfully submit that material 70 could not and would not function as an insulating hardmask as suggested in the Office action, and claims 6 and 7 are therefore further distinguished from Chooi.

Based on the above, the rejection of claims 6 and 7 under 35 U.S.C. §103(a) as being unpatentable over Chooi, in view of Bjorkman, should be withdrawn.

* Claims 11, 12 and 14

Claim 11 is an independent claim from which claims 12-14 depend. Claim 11 has been amended and amended independent claim 11 now recites the features of:

a lower low-k dielectric film;
an etch-stop layer formed over said low-k dielectric film;

an upper low-k dielectric film formed over said etch-stop layer; and
a hardmask layer formed over said upper low-k dielectric film, each of said
etch-stop layer and said hardmask layer formed of oxygen-doped silicon carbide.

As discussed above in connection with claim 1, Chooi does not disclose or suggest a low-k dielectric film. The only dielectric matter taught by Chooi is *air*, which is clearly not a film. As such, Chooi cannot and does not disclose a film stack including a lower low-k dielectric film, an etch-stop layer formed over the low-k dielectric film, an upper low-k dielectric film, and a hardmask layer formed over the upper low-k dielectric film, as in amended claim 11. Therefore, amended independent claim 11 recites features neither disclosed nor suggested by Chooi. Amended independent claim 11 is therefore distinguished from the reference of Chooi.

Bjorkman has apparently been relied upon for providing an oxygen-doped silicon carbide for an insulating film and an insulating hardmask. Even if Bjorkman taught an oxygen-doped silicon carbide film as alleged by the Examiner, Bjorkman would not make up for the above-stated deficiencies of Chooi. Claim 11, and claims 12 and 14 which depend from claim 11, therefore recite features that distinguish Applicants' invention from the references of Chooi and Bjorkman, taken alone or in combination.

Applicants also respectfully point out that Bjorkman does not disclose an oxygen-doped silicon carbide layer for reasons set forth above. Bjorkman therefore cannot and does not disclose an oxygen-doped silicon carbide layer as an etch-stop layer formed over a low-k dielectric film or as a hardmask layer formed over an upper low-k dielectric film formed over the etch-stop layer. As such, claims 11, 12 and 14 are further distinguished from the references of Chooi and Bjorkman, taken alone or in combination.

Therefore, the rejection of claims 11, 12 and 14 under 35 U.S.C. §103(a) as being unpatentable over Chooi in view of Bjorkman, should be withdrawn.

* Claim 15

Independent claim 15 has been amended to more clearly point out applicants' invention. As amended, claim 15 recites the features of:

a copper-containing surface;

a nitrogen-containing first barrier layer disposed over said copper-containing surface;
an oxygen-doped, substantially nitrogen-free second barrier layer disposed over said first barrier layer;
a first low-k dielectric film disposed on said second barrier layer.

Since claim 15 recites a first low-k dielectric film disposed on the second barrier layer, claim 15 is distinguished from the reference of Chooi which does not disclose a low-k dielectric film at all, as discussed above. Chooi therefore cannot and does not disclose a first low-k dielectric film disposed on the second barrier layer. Amended independent claim 15 is therefore distinguished from Chooi.

Also for reasons set forth above, the cited reference of Bjorkman does not make up for the above-stated deficiencies of Chooi. As such, amended independent claim 15 is distinguished from the references of Chooi and Bjorkman, taken alone or in combination. Therefore, the rejection of claim 15 under 35 U.S.C. §103(a) as being unpatentable over Chooi in view of Bjorkman, should be withdrawn.

V. Rejection of Claim 8 under 35 U.S.C. §103

In the Office Action, specifically in paragraph 10, claim 8 was rejected under 35 U.S.C. §103(a) as being unpatentable over Chooi in view of Grill et al. (U.S. Pat. No. 6,140,226), hereinafter "Grill". Applicants respectfully submit that this claim rejection is overcome based on the reasons set forth below.

Claim 8 depends from amended independent claim 1 which is distinguished from Chooi for reasons set forth above. The cited reference of Grill has apparently been relied upon for disclosing a low-k dielectric film being formed of SiOC-H. The cited reference of Grill does not make up for the above-stated deficiencies of Chooi. One of ordinary skill in the art would have no motivation to modify Chooi, which does not disclose or suggest a low-k dielectric film at all, by using a low-k dielectric film formed of SiOC-H as in Grill.

Moreover, Grill does not teach or suggest the feature of a barrier layer disposed between a copper-containing structure and a low-k dielectric film formed of SiOC-H, the barrier layer comprising a composite film structure including a nitrogen-containing,

substantially oxygen-free first film forming a boundary with the copper-containing structure and an oxygen-containing, substantially nitrogen-free second film forming a boundary with the low-k SiOC-H dielectric film. As such, independent claim 1 and therefore dependent claim 8, each recite features neither disclosed nor suggested by the references of Chooi and Grill, taken alone or in combination.

The rejection of claim 8 under 35 U.S.C. §103(a) as being unpatentable over Chooi in view of Grill, should therefore be withdrawn.

VI. Rejection of Claim 13 under 35 U.S.C. §103

In the Office Action, specifically in paragraph 11, claim 13 was rejected under 35 U.S.C. §103(a) as being unpatentable over Chooi et al. and Bjorkman as applied to claim 11 above and further in view of Kariya. Applicants respectfully submit that this claim rejection is overcome based on the reasons set forth below.

Claim 13 depends from amended independent claim 11, which is distinguished from the references of Chooi and Bjorkman for reasons set forth above. Claim 13 recites the features of a nitrogen-doped silicon carbide film and an oxygen-doped silicon carbide film, and incorporates the features of claim 11 from which it depends. The cited reference of Kariya has apparently been relied upon for providing nitrogen-doped silicon carbide and oxygen-doped silicon carbide. Kariya therefore does not make up for the above-stated deficiencies of the combination of Chooi and Bjorkman. Independent claim 11, and therefore also dependent claim 13, each therefore recite features that distinguish applicant's invention from the references of Chooi, Bjorkman, and Kariya, taken alone or in combination.

Moreover, applicants respectfully submit that the ordinary artisan would not have been motivated to modify the integrated circuit of Chooi, modified by Bjorkman, by using the teachings of Kariya to decrease light absorption as suggested in the Office action, for reasons set forth above.

Therefore, the rejection of claim 13 under 35 U.S.C. §103(a) as being unpatentable over Chooi and Bjorkman as applied to claim 11 above, and further in view of Kariya, should be withdrawn.

VII. Claims 16-14

Claims 16-24 were previously withdrawn from consideration and are hereby cancelled.

CONCLUSION

Based on the foregoing, each of claims 1-15 is in allowable form and the application is therefore in condition for allowance, which action is respectfully and expeditiously requested.

Attached hereto is a marked-up version of the changes made to the above-identified application by the current amendment. The attached page is captioned "Version with markings to show changes made."

Respectfully submitted,

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VERSION WITH MARKINGS TO SHOW CHANGES MADE

Amend claims 11-13 and 15, as indicated.

11. (Amended) A semiconductor product comprising a film stack including:
a lower low-k dielectric film [layer];
an etch-stop layer formed over said low-k dielectric film [layer];
an upper low-k dielectric film [layer] formed over said etch-stop layer; and
a hardmask layer formed over said upper low-k dielectric film [layer], each of said etch-stop layer and said hardmask layer formed of oxygen-doped silicon carbide.
12. (Amended) The semiconductor product as in claim 11, in which said film stack includes a two-tiered opening formed therein, said two-tiered opening including a wider upper portion disposed over a narrower lower portion,
said narrower lower portion extending through said lower low-k dielectric film [layer],
said wider upper portion extending through said etch-stop layer, said upper low-k dielectric film [layer] and said hardmask layer, and
said two-tiered opening filled with a conductive material.
13. (Amended) The semiconductor product as in claim 12, further comprising a composite film structure formed beneath said lower low-k dielectric film [layer] and including a nitrogen-doped silicon carbide film formed beneath an oxygen-doped silicon carbide film, and wherein said narrower lower portion further extends through said composite film structure and said two-tiered opening extends to a bottom surface formed of a further conductive material.
15. (Amended) A semiconductor product comprising a film stack including:
a copper-containing surface;
a nitrogen-containing first barrier layer disposed over said copper-containing surface;

an oxygen-doped, substantially nitrogen-free second barrier layer disposed over said first barrier layer;

a first low-k dielectric film disposed on [over] said second barrier layer;

an oxygen-doped silicon carbide etch-stop layer disposed over said first low-k dielectric film;

a second low-k dielectric film disposed over said etch-stop layer; and

an oxygen-doped silicon carbide hardmask film disposed over said second low-k dielectric film.